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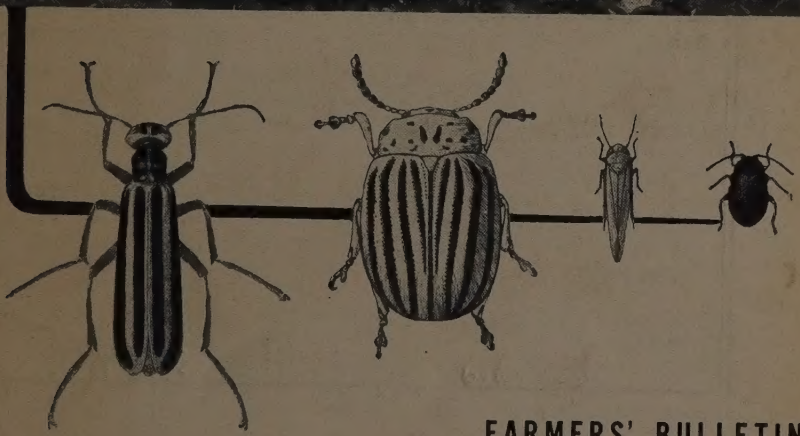
Control of POTATO INSECTS



FARMERS' BULLETIN
No. 2040

U. S. DEPARTMENT OF AGRICULTURE

THERE are more than 100 insect pests of the Irish potato. Learn to recognize those that are common to your area.

No one insecticide will control all these insects. Select the one most suitable for your problem.

Use good equipment capable of getting insecticides to all parts of the plants. Keep this equipment clean and in good working order at all times.

Make careful and timely applications. Look upon spraying or dusting as a form of crop insurance, and see that applications are begun before damage occurs.

Take proper precautions to guard your health while handling or applying insecticides.

Successful control with insecticides depends on the careful preparation and application of dusts, sprays, or poisoned baits.

Superseded by Bulletin 2165

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CONTROL OF POTATO INSECTS[1]

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THE COMMON white, or Irish, potato is attacked by many kinds of insect pests. The production of a marketable crop depends largely on the development of healthy plants that are not injured by these pests or by the diseases that they transmit. Any method of controlling insects and keeping the plants healthy and free from injury helps to improve both the size and the quality of the tubers.

Some potato insects bite out parts of the leaf, stem, or tuber; others suck sap or juices from some part of the plant. The Colorado potato beetle, flea beetles, blister beetles, stalk borers, and grasshoppers eat the foliage, and the damage may be readily seen and its importance realized. Other biting insects, such as wireworms, white grubs, cutworms, and some flea beetles, attack the tubers and the damage may not be noticed until harvest. The damage from sucking insects, which include leafhoppers, aphids, and the potato psyllid, is also not readily noticed and often becomes extensive before control measures are begun.

[1] Several of the photographs in this bulletin are used through the courtesy of the Wisconsin or Maine Agricultural Experiment Stations.

[2] Retired October 31, 1951.

Insects such as the Colorado potato beetle, flea beetles, leafhoppers, aphids, the potato psyllid, and grasshoppers are injurious in both the adult and immature forms, whereas wireworms, cutworms, and stalk borers cause damage only as larvae. Some insects either cause or transmit diseases that may do more damage than the direct feeding injury. The insects associated with potato diseases include aphids, leafhoppers, and the potato psyllid.

Insects that bite potato foliage can be killed by applying an insecticide spray or dust which they will swallow with the foliage. The arsenicals and cryolite are suitable for this purpose. Grasshoppers, armyworms, and cutworms can be killed by applying poison baits. For sucking insects, on the other hand, it is necessary to use an insecticide that will kill by contact, such as nicotine sulfate, pyrethrum, or sulfur. DDT, parathion, and rotenone not only kill by contact but also kill certain insects that eat the treated foliage.

Against some insects insecticides are of little value; only cultural practices afford control. Such practices include (1) plowing at special times and in special ways, (2) control of weeds and other alternate hosts of certain insects, (3) crop rotation to avoid planting potatoes on insect-infested land, (4) disposal of crop remnants by plowing under or by burning, and (5) digging furrows to trap certain insects. Natural enemies and the weather may play important parts in the control of some insect pests.

PRECAUTIONS IN HANDLING INSECTICIDES

Most insecticides are poisons. Handle them with great care. Store them in closed containers where they cannot be mistaken for food or medicine, and where children or farm animals cannot reach them. See that the containers are properly labeled.

Some insecticides, such as nicotine, calcium cyanide, methyl bromide, and parathion, give off vapors that are highly toxic if breathed. Others, including ethylene dibromide, lime-sulfur, and copper sulfate, will burn the skin.

When mixing insecticides, wear gloves to protect your hands. If a fine dust or fumes fill the air, wear a mask to protect your nose and mouth. Wear goggles to protect your eyes from fine dust and spattering liquids. Even though your hands and face have been protected during the mixing, wash them with soap and water after the process is completed.

When mixing baits, wear rubber or leather gloves to protect your hands. If bait is not spread as soon as mixed, see that all containers in which it is kept are prominently labeled POISON and kept away from children and farm animals.

Wash all utensils and tools thoroughly as soon as mixing is completed.

Parathion and TEPP are extremely dangerous poisons. They should be used only by trained operators, who will assume full responsibility and enforce proper precautions, as prescribed by the manufacturers. A person applying them should wear a tight-fitting gas mask or respirator, equipped with a canister specified for use in handling organic vapors, acid gases, and dusts.

Parathion, TEPP, chlordane, and toxaphene are absorbed through the skin. A person handling or applying these materials should wear

protective clothing, keep the shirt buttoned at the neck, keep the sleeves rolled down, and bathe and wash clothing daily.

HOW TO PREPARE INSECTICIDE MIXTURES

Many insecticides may be purchased either as ready-to-apply dusts, which need no further dilution, or as concentrates, which must be diluted before application as dusts or sprays. The care with which insecticide mixtures are prepared largely determines their effectiveness. To obtain the correct proportions of different ingredients, you will need a platform or spring-type scale graduated in ounces or in tenths of a pound.

DUSTS

Most of the common dusts can be purchased ready-mixed at proper dilution for application, but some growers prefer to buy the ingredients and mix them.

To calculate the number of pounds of a dust concentrate to use, multiply the desired percentage of toxic substance in the final dust by the number of pounds to be made and divide by the percentage of toxic substance in the concentrate. For example, suppose you wish to prepare 100 pounds of a 5-percent DDT dust from a 50-percent dust concentrate. To determine the quantity of this concentrate to use, multiply 5 by 100 and divide by 50. This computation shows that 10 pounds of the concentrate is needed; add 90 pounds of talc, pyrophyllite, or other diluent.

Arsenicals and dry concentrates can be diluted with talc, hydrated lime, clay, and the like, but some kind of a revolving mixer is needed to do a thorough job. A barrel or metal drum with a hole in the side and a tight-fitting cover can be mounted on an axle extending through the ends and turned by a handle. When no liquid is to be included, such a piece of apparatus makes a fairly satisfactory dust mixer. However, a power-driven revolving mixer is preferable. Most dusts are mixed more quickly and thoroughly if the mixer contains a pailful of stones the size of hens' eggs.

To prepare dusts containing nicotine sulfate or liquid conditioning agents, such as oils and soaplike liquids, a revolving mixer is needed. It is best to spray the liquids into the mixer while it is in operation.

SPRAYS

For preparing sprays it is important to have good equipment, such as tight barrels or kegs, pails that do not leak, funnels of proper size fitted with wire strainers, scales, and standard pint, quart, and even gallon measures. For small quantities glass or metal measures graduated in fluid ounces are useful.

To calculate the quantity of concentrate to use, multiply the percentage of toxic substance desired in the finished spray by the number of gallons to be made by the approximate weight of the water, and divide by the percentage of toxic substance in the original material. For example, if 100 gallons of a spray containing 0.02 percent of rotenone is to be prepared from derris or cube powder containing 5 percent of rotenone, multiply 0.02 by 100 by $8\frac{1}{3}$ (the approximate weight in pounds of a gallon of water) and divide by 5. The result

is 3⅓ pounds of derris or cube. Equivalent quantities of concentrates for preparing sprays with 100 gallons and with 1 gallon of water are given below. The equivalents for dry materials are applicable to DDT wettable powder, calcium arsenate, and other products of about the same weight per unit volume. For sulfur or lime use one-half and for paris green one-fourth the quantities given to 1 gallon of water.

When using a powder in preparing a spray, first mix it with a little water to form a thick paste, add more water until you have a thin paste, and then funnel it into the spray tank and stir the mixture well. Always prepare a spray just before you apply it.

Quantities of insecticide concentrate to use with 100 gallons and 1 gallon of water

Dry materials		Liquids	
100 gallons	1 gallon	100 gallons	1 gallon
Pounds	*Tablespoonfuls* [1]	*Quarts*	*Teaspoonfuls*
1	1	¼	½
2	2	½	1
3	3	1	2
4	[2] 4	1½	[3] 3
5	5	2	4
6	6	2½	5
7	7	3	[4] 6
8	[5] 8	3½	7
9	9	4	8
10	10	6	[2] 12
12½	12	10	19

[1] All measurements level.
[2] ¼ cupful.
[3] 1 tablespoonful.
[4] 1 fluid ounce.
[5] ½ cupful.

POISONED BAITS

Baits must be thoroughly mixed. They may be mixed in a pail or wooden box, in a wagon box, on the floor of the barn or shed, or by means of a mechanical device such as a seed-treating machine, concrete mixer, or large mixing machine designed for the purpose.

When using a powdered poison, such as sodium fluosilicate or paris green, first mix it thoroughly with dry bran, sawdust, or other bulk material, and then sprinkle water on to this mixture as you continue mixing. Liquids should be diluted with the water first.

In preparing bait containing water use only as much water as the bait will readily absorb. Too much water will make the particles stick together and fall as small lumps. Lumps are much less effective than flakes; besides, they may be eaten by poultry or farm animals.

All the bait formulas give only approximate quantities of water; the exact quantity depends on how dry the other materials are.

HOW AND WHEN TO APPLY INSECTICIDES

Proper and timely application of insecticides is just as important as their preparation. You must know what part of the plant an insect infests in order to put the insecticide where it will do the most good.

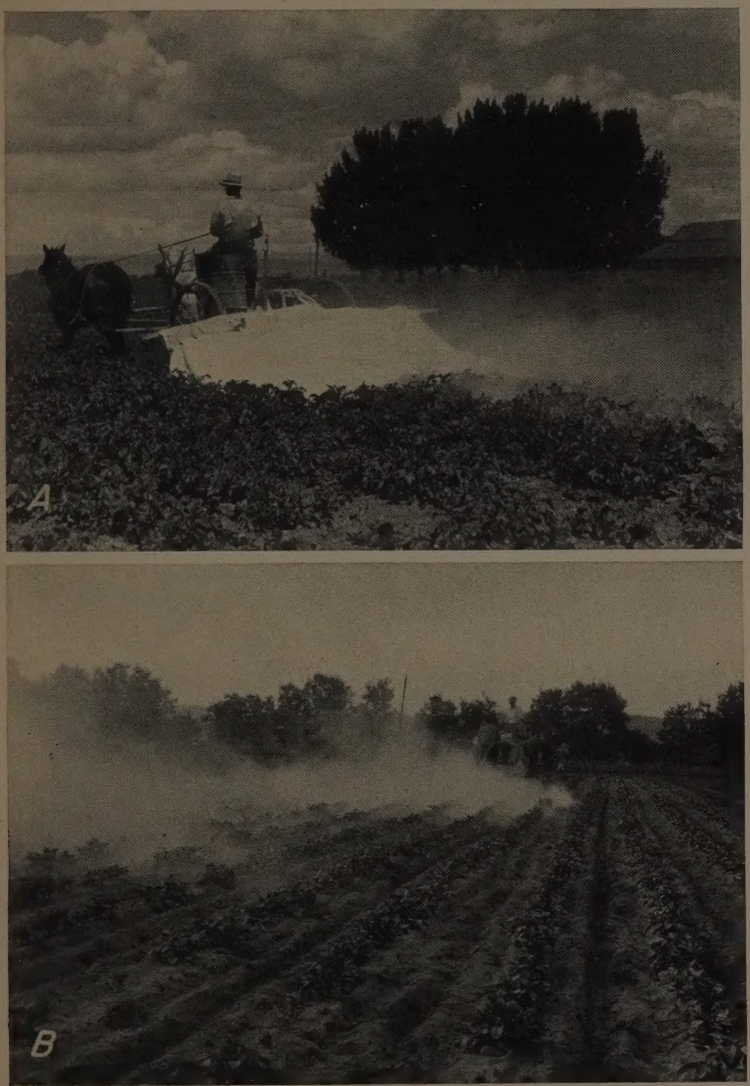

Figure 1.—Applying insecticide dusts to potatoes. *A*, A short apron attached to the duster aids in confining the dust to the foliage. *B*, Without an apron most of the dust is blown away.

With some insecticides, such as nicotine, it is necessary to hit the insects to kill them; with others, such as the arsenicals used against the Colorado potato beetle, you need only to cover the upper surface of the foliage. When using DDT against aphids or the potato psyllid, direct the spray or dust to the under side of the leaves to hit and kill the nymphs.

Care in applying the right quantity of insecticide to a given area goes a long way toward bringing about satisfactory control. Too little is likely to be ineffective; too much is wasteful.

Insecticides should generally be applied early in the season, when only a few insects are present and before they have caused appreciable injury. Dusts should be applied when there is little or no wind. A muslin or lightweight canvas apron, 12 to 20 feet long, attached to the top of the duster boom, helps keep the dust from blowing away (fig. 1). Weighting the apron with ropes fastened lengthwise holds it closer to the plants. An apron should not be used when plants are wet.

Insecticides, especially sprays, do not adhere well to foliage that is dripping wet with rain or dew. Do not apply them just before a rain is expected. Insecticides containing nicotine sulfate are not very effective unless the temperature is above 70° F.

GROUND DUSTERS

There are many types of dusters, ranging from small hand-operated types suitable for small gardens up to large, powered outfits capable of covering swaths up to 40 feet wide.

The plunger-type duster, although effective if properly used, is suitable only for very small gardens.

For larger gardens the bellows (fig. 2) and fan types of dusters are

Figure 2.—Bellows-type duster.

suitable. The bellows, or knapsack, duster is carried on the back. One hand operates the bellows lever; the other hand directs the nozzle. This duster does not produce a continuous stream of dust, and therefore is more suitable for crops grown in hills than for row crops, although it can be used for both kinds. The fan, or blower, duster is generally strapped to the front of the operator's body and held steady with one hand while the other hand turns the handle that rotates the fan. The one or two nozzles are directed by the operator turning his body. This duster delivers a continuous stream of dust and is best suited to row crops.

Traction dusters are usually mounted on two wheels, and may be pushed by the operator or horse-drawn. They may cover swaths from 6 to 24 feet wide.

Figure 3.—Four-row, horse-drawn power duster with two nozzles to the row.

Power dusters (fig. 3) are operated by gasoline-driven engines or by power take-off from tractors. Most of them are attached to a framework on wheels, or are mounted on an automobile truck or a tractor. Booms may be from 12 to 24 feet long, and those specially ordered for engines of high horsepower may cover a 40-foot swath.

GROUND SPRAYERS

Two types of sprayers are available for use in small- and medium-size gardens, the knapsack sprayer and the compressed-air sprayer. The knapsack sprayer is similar in operation to the knapsack duster, except that a continuous stream of spray is produced at a pressure of 75 to 100 pounds per square inch.

The compressed-air sprayer consists of an airtight tank, which is filled and pumped up to the proper pressure. As soon as the spray becomes coarse, the sprayer must be pumped up again. One drawback to this type of sprayer is the lack of uniformity in pressure during its operation. Small compressed-air sprayers are carried on the operator's back. The larger ones are mounted on one or two wheels and pushed by one operator while another directs the nozzle.

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Traction sprayers are mounted on wheels, to one of which the pump is geared. A continuous pressure of 125 to 250 pounds per square inch can be maintained. These sprayers are usually horse drawn.

Power sprayers have one or more pumps driven by a gasoline engine or by power take-off from a tractor. They range from 10- to 50-gallon tank outfits with single-cylinder pumps, which maintain pressures of 150 to 200 pounds, to large rigs having a tank capacity of 400 gallons or more and multiple-cylinder pumps capable of maintaining pressures up to 600 pounds per square inch. Power sprayers may be horse drawn or tractor drawn (fig. 4), or mounted on automobile trucks, or they may be self-propelled outfits.

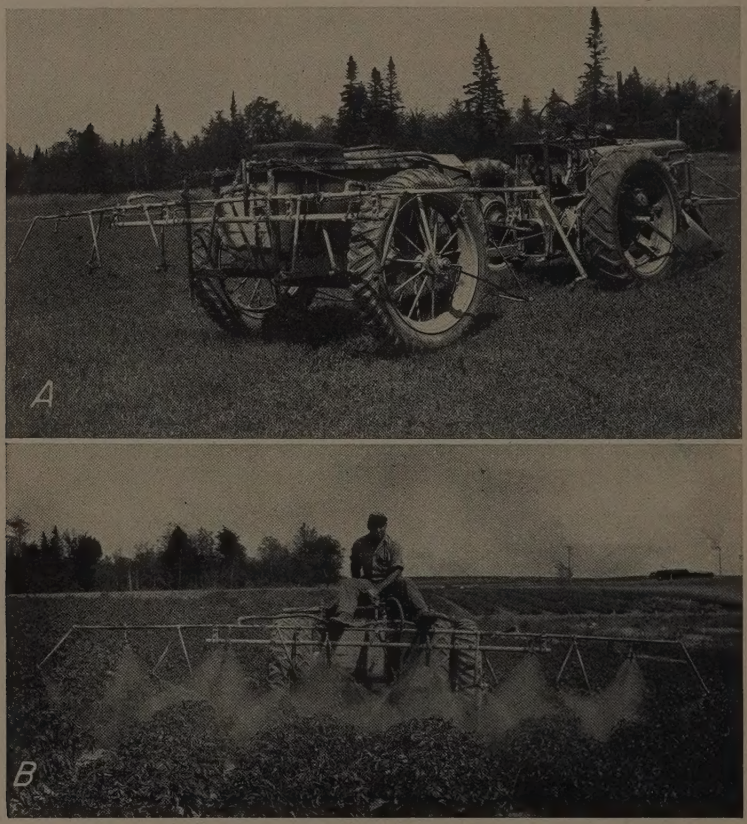

Figure 4.—A, Tractor-drawn power sprayer. B, Same sprayer applying insecticide to a potato field.

The usual rate of application of sprays with conventional ground sprayers is 100 to 125 gallons per acre. Recent experiments show that by the use of special equipment equally good control of certain insects, such as aphids, flea beetles, leafhoppers, and the Colorado potato beetle, can be obtained with the same quantity of toxic in-

gredient in only 50 gallons or even as little as 25 gallons per acre. Such sprays are called low-gallonage sprays. The lower the gallonage applied per acre, the more concentrated the spray must be if it is to contain the same quantity of insecticide. Low-gallonage sprays can also be applied with conventional sprayers by reducing the pressure and using disks having smaller apertures.

Although the low-gallonage sprays have shown promise against some potato insects, until tested further they should be used with caution and should not entirely replace the high-gallonage sprays.

AIRCRAFT APPLICATION

Aircraft is rapidly coming into use for applying dusts and concentrated sprays for the control of certain potato insects. Several types of airplanes are employed, and many commercial companies specialize in the aerial application of insecticides. The use of aircraft is particularly advantageous when the soil is too wet to use ground equipment, when the vines are large and cover the ground, or when a large acreage must be treated at once. On the other hand, until methods and equipment for aircraft applications are further developed, they may not be so effective as ground applications.

INSECTS THAT CAUSE THE MOST WIDESPREAD DAMAGE

APHIDS

At least four kinds of aphids, or plant lice, attack potato foliage. The green peach aphid and the potato aphid cause the most damage. They are distributed generally over the United States and attack many kinds of food and ornamental plants. The others, the buckthorn aphid and the foxglove aphid, are restricted chiefly to the Northeastern States.

Nature of Injury

Both adult aphids and their young, called nymphs, suck the sap from potato foliage. Except for being smaller and wingless, the nymphs resemble the adults closely. Aphids are very sluggish and generally remain almost motionless while the plants are being examined.

Aphids reproduce rapidly in warm weather. If no control measures are used, every plant may soon become infested with hundreds of aphids. They suck the sap and cause the leaves to curl downward, become yellow, and die (fig. 5). When the infestation is severe, entire fields of potatoes may be destroyed. The hotter the weather and the drier the soil, the greater is the damage from the loss of a given quantity of sap. Very hot, dry weather, however, may greatly reduce the aphid population.

The green peach and potato aphids also transmit at least five of the virus diseases of the potato—leaf roll (one cause of net necrosis in tubers), mild mosiac, rugose mosaic, spindle tuber, and unmottled curly dwarf. The green peach aphid is the most important vector of four of these diseases. The buckthorn aphid and the foxglove aphid transmit leaf roll and mild mosaic. The total damage caused by aphids attacking potatoes is thus of vital concern to potato growers.

Figure 5.—Potato foliage with leaves curled downward owing to injury by aphids. By the time these symptoms appear most of the damage has been done.

Seasonal History and Habits

The adult potato aphid is about one-sixth of an inch long and may be green or pink (fig. 6). The adult green peach aphid is much smaller and is greenish or yellowish green. The adult buckthorn aphid is even smaller than the green peach aphid; it is yellow to dark green or almost black. The adult foxglove aphid is also green, larger than the green peach aphid but smaller than the potato aphid.

Most aphids are wingless, but some winged forms can nearly always be found during the growing season. In the late summer and fall in the North the aphids fly to their winter hosts, and the eggs laid by their progeny survive the winter and hatch in the spring. The wingless aphids from these eggs produce winged forms, which fly from winter hosts to weeds, and to potato and other crops. The largest number of winged forms appear in midsummer and late summer. They disperse from plants on which they developed and, often filling the air, scatter over the countryside to light on potato and other food plants. During the potato-growing season these aphids deposit living young, all of which are females. Within 2 to 3 weeks one female may deposit from 50 to 100 young. As the nymphs mature in 1 to 2 weeks in favorable weather, a very rapid increase in population is possible.

The potato aphid feeds on the potato leaves, but during the flowering period it is most abundant on the blossoms and tender terminal growth. The other three kinds of aphids infest the middle and lower parts of the plants more heavily than the top parts, and thus may not be so readily noticed as is the potato aphid. In heavy infestations the leaves and stems become glazed with a sweetish, sticky excretion called honeydew. Later, mold develops on the honeydew, giving the plants a sooty appearance.

In the northern half of the country these aphids overwinter in the egg stage—the potato aphid principally on wild rose bushes, the green peach aphid on peach and plum, and the buckthorn aphid on buckthorn. In Maine the foxglove aphid is known to overwinter on the foxglove plant, but other plants may also serve as overwintering hosts. In the South aphids usually do not lay eggs but deposit living young throughout the winter.

Figure 6.—Potato aphids on the stem of a potato plant.

In the State of Washington as many as 19 generations have developed during a summer. In warmer areas there may be more, but the number is limited by the period during which potatoes are growing.

The numbers of each kind of aphid vary greatly from year to year. Epidemics of the potato aphid occur less frequently than those of the other kinds.

Control

Effective means of controlling aphids vary in different parts of the country. In some sections the destruction of their winter host plants should reduce aphid damage to potatoes. To make this practice effective a thorough knowledge of the kinds and locations of such hosts and a systematic and thorough program for their destruction over a large area are necessary.

Large numbers of aphids are produced on certain weeds, whether growing on uncultivated land or among crops. These weeds should be destroyed.

Aphids on potatoes can be killed by applying a spray or dust containing DDT, parathion, rotenone, or nicotine. DDT and parathion are the most effective, but DDT sometimes does not give good control of the potato aphid, and the application of parathion requires special precautions (p. 2). DDT has the advantage of controlling most other insects that attack potatoes. In humid sections these insecticides are frequently applied in fungicide mixtures for the control of both aphids and potato diseases. DDT, parathion, and rotenone deteriorate rapidly when mixed with fungicides containing hydrated lime; therefore, these insecticides should not be put in mixtures containing lime unless they are applied immediately after preparation. It is preferable to use either a neutral copper compound, such as copper oxide or tribasic copper sulfate, or an organic fungicide, such as zineb or nabam. Nicotine sulfate, however, should be applied in mixtures containing hydrated lime.

Watch potatoes carefully for the appearance of aphids. Begin insecticide applications early in the season while populations are still low and repeat once a week until the danger of aphid damage has passed. Where aphids require control every year, as in northeastern Maine, make the first application as soon as they appear on the plants, which may be even before all the plants are up.

Sprays

Sprays are very effective, although not very practical in the irrigated sections of the Northwest. The following quantities of insecticides per acre should give satisfactory results when added to 125 gallons of water or fungicide spray, or to smaller quantities if special equipment is used:

DDT, 2½ pints of a 25-percent emulsifiable concentrate or 3¾ pounds of a 50-percent wettable powder. If the fungicide is bordeaux mixture, use 5 pounds of DDT wettable powder.

Parathion, 10 fluid ounces of a 25-percent emulsifiable concentrate or 1 pound of a 15-percent wettable powder or 10 ounces of 25-percent wettable powder.

Derris or cube, 5 pounds of powder containing 5 percent of rotenone. Add a wetting agent as recommended on the container. The addition of 1 pint of soybean oil increases the effectiveness of this spray.

Nicotine sulfate (40 percent nicotine), 1½ pints.

Arrange the nozzles so as to direct the insecticide to the under side of the leaves, particularly the lower leaves, where many of the aphids may be located.

Dusts

Dusts are preferred to sprays in dry areas, where water is scarce and rain is not likely to wash the dust off the plants. Care must be taken not to let the dusts blow away before they reach the insects. An apron dragged behind the boom makes it easier for dust to penetrate the foliage.

In the irrigated sections of the Northwest, use a ready-mixed dust containing 5 percent of DDT, 0.5 percent of parathion, and 50 percent of dusting sulfur, with the remainder talc or pyrophyllite. Make five applications at the rate of 25 to 35 pounds per acre at 10- to 14-day intervals, beginning when one-fourth of the plants are up. Where humidity is high, sulfur may injure potato foliage and should not be used. In such areas the following dusts are effective when applied at 35 pounds per acre as needed. A neutral copper fungicide may be included in each dust.

DDT, 3 percent in talc or pyrophyllite plus 2 percent of a nonvolatile oil.

Parathion, 1 percent. Do not prepare your parathion dust; buy it ready mixed.

Derris or cube to contain 1 percent of rotenone in talc or pyrophyllite.

Nicotine sulfate (40 percent nicotine) to contain 3 percent of nicotine in hydrated lime, or 4 percent if the potato aphid is present.

COLORADO POTATO BEETLE

The Colorado potato beetle is one of the most widespread and destructive potato pests in this country. It also attacks related plants, such as tomato, eggplant, and belladonna. Both adults and larvae feed on the leaves of their hosts. If not controlled, they may consume all the foliage, leaving a field of bare stems.

The potato beetle is one of the agents that spread several potato diseases, including brown rot (bacterial wilt), spindle tuber, and ring rot (bacterial ring rot).

Seasonal History and Habits

The adults are hard-shell beetles, stout, oval, and strongly convex, about three-eighths inch long and one-fourth inch wide, with black and yellow stripes running lengthwise along their wing covers (fig. 7). Orange-yellow eggs are laid in masses of 10 to 30 or more on the under sides of the leaves, and 1 female may deposit 300 or more eggs in 4 to 5 weeks. The larvae, known as slugs, soft-shells, and grubs, are dark red when young but become orange as they grow. They have two conspicuous rows of black spots along the sides of the body. When mature they enter the soil and pass through the pupal stage to adults. The life cycle requires about 1 month.

Over most of their range the adults spend the winter in the ground, emerging in the spring to lay eggs about the time the first potatoes are up. The earliest plantings are likely to be the most seriously injured.

In the extreme northern part of the United States only one generation may occur annually, but in the southern part as many as three may develop on potatoes and other plants.

Figure 7.—Life stages of the Colorado potato beetle.

Control

Adults and larvae of the Colorado potato beetle can be controlled with DDT, arsenicals (calcium arsenate, lead arsenate, and paris green), cryolite, and rotenone. The insecticides may be applied either as dusts or as sprays. Frequently they are combined with copper-containing fungicides used for the control of certain potato diseases. The strengths at which these insecticides should be employed are as follows:

Dusts

DDT, 3 percent in talc or pyrophyllite in the East and 5 percent in the West.
Calcium arsenate, 1 part; hydrated lime or talc, 3 parts.
Paris green or lead arsenate, 1 part; hydrated lime or talc, 8 to 10 parts.
Cryolite and talc, equal parts.
Derris or cube, to contain 0.75 percent of rotenone in talc or pyrophyllite.

Hydrated lime should not be used as the diluent in dusts containing DDT, cryolite, or rotenone.

Apply about 20 pounds of dust per acre when the plants are small and up to 40 pounds as they become larger.

Sprays

The following quantities of insecticide concentrate should be applied per acre in water or fungicide spray:

DDT, 3 pounds of a 50-percent wettable powder. If the fungicide is bordeaux mixture, use twice as much DDT.
Paris green, 2 pounds plus hydrated lime, 4 pounds.
Calcium arsenate or lead arsenate, 4 pounds.
Derris or cube, 4 pounds of a powder containing 5 percent of rotenone.

If using a conventional spray, apply 80 to 125 gallons per acre, depending on the size of the plants. For best results make the first application as soon as the grubs appear.

FLEA BEETLES

Many kinds of small leaf-feeding beetles, appropriately called flea beetles, spring from the plants when approached.

Two kinds are major pests of potato—the potato flea beetle and the tuber flea beetle. The potato flea beetle may severely damage potato foliage, but its larvae seldom feed on the tubers. The tuber flea beetle damages the foliage and its larvae are serious pests of the tubers. Other flea beetles which now and then attack both potato foliage and tubers are the tobacco flea beetle, the eggplant flea beetle, the western potato flea beetle, the pale-striped flea beetle, and the banded flea beetle.

Nature of Injury

The adult flea beetles chew small holes in the leaves, giving them a sievelike appearance (fig. 8). Badly eaten leaves wither and die, and tuber growth is thereby reduced. Flea beetles are known to transmit potato diseases, such as spindle tuber and brown rot, and the leaf wounds no doubt are entries for air- or water-borne diseases. The potato flea beetle and the banded flea beetle carry the unmottled curly dwarf disease.

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Figure 8.—Potato leaf with many small holes eaten by potato flea beetles.

Flea beetle larvae attack the underground parts of their host plants. Certain kinds, particularly those of the tuber flea beetle, scar the surface of potato tubers or may bore into them, discoloring and thereby causing waste when the potatoes are pared for use (fig. 9). Their feeding is often responsible for infections of potato scab and rhizoctonia disease.

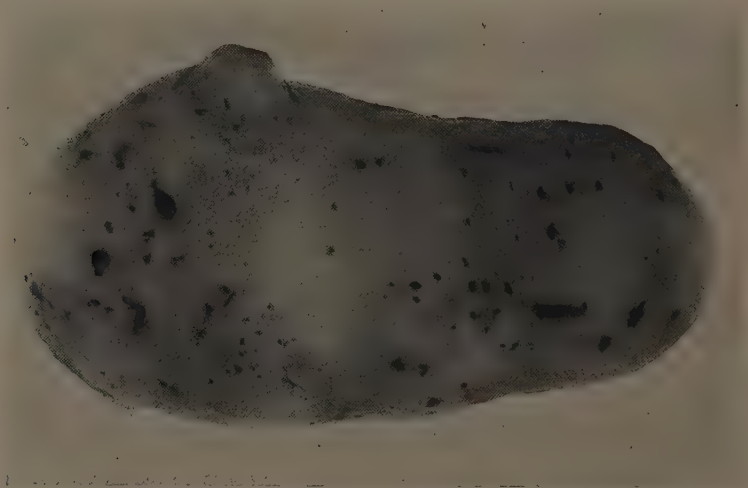

Figure 9.—Potato injured by flea beetle larvae. The holes continue into the flesh of the tuber.

In the Northeast, where the potato flea beetle has only one generation annually, its larvae seldom damage the tubers. The greatest injury is done by the adults eating holes in the leaves soon after the plants have come up and, again in August, when a new generation emerges from the soil.

Adults of the different flea beetles range from one-sixteenth to one-eighth inch in length. Some are entirely black, some are yellowish brown, and others have yellowish stripes running lengthwise along the wing covers (fig. 10). Flea beetles hibernate, usually as adults,

Figure 10.—Potato flea beetle. (Enlarged.)

in the soil, in crop remnants, and in grass or weeds growing along the edges of fields and woods.

Eggs, so small that they are rarely seen, are deposited in cracks in the soil. Eggs of most kinds of flea beetles hatch within a week. The threadlike larvae are about one-third inch long when full grown. They pupate in the soil. The life cycle is usually completed in about 6 weeks, although 8 or 9 weeks may be required. Flea beetles have from one to four or more generations each year, depending on their kind and on the part of the country in which they occur.

Control

Flea beetles may be controlled with the DDT, arsenical, cryolite, and rotenone mixtures recommended for the control of the Colorado potato beetle (p. 14). Over the country as a whole, however, DDT has given most satisfactory results. A 3-percent dust is recommended in the East and 5-percent dust in the West. A neutral copper fungicide may be included in the dust to control blight in the East.

In sprays, 3 pounds of 50-percent DDT wettable powder should be used per acre in water or neutral copper fungicide spray, or 6 pounds in bordeaux spray. Bordeaux mixtures that contain an excess of lime, such as 8–12–100 or 8–16–100, are of some value in repelling flea beetles, but they are not recommended for use in the West.

Dusts should be applied at the rate of 20 to 35 pounds per acre, depending on the size of the plants. A lightweight canvas apron, 12 to 20 feet long, should be attached to the boom of the duster. With ordinary equipment, sprays should be applied at the rate of 80 to 125 gallons per acre at a pressure of 250 pounds per square inch or more, and preferably with three nozzles to the row.

The number of applications necessary for satisfactory control varies with the locality and the time of the season during which the crop is grown. Three to six applications are required in the West and frequently more are needed in the East.

In the West where the tuber flea beetle occurs, do not delay treatment until foliage injury appears. Begin applications as soon as beetles appear, usually when the plants break ground. A few adults early in the season are enough to cause economic damage to tubers. Make two or three applications at 7- to 10-day intervals, and additional applications when five or more beetles are collected per 10 sweeps of an insect net. If a fancy grade of potatoes is to be produced, or if the crop is to be dehydrated, beetle populations must be held at an extremely low level throughout the season. Even if the fields have been kept fairly free of beetles before the vines became matted in the rows, an application may be necessary about 15 days before digging.

GRASSHOPPERS

Many kinds of grasshoppers, including some migratory ones known as locusts, are among the most injurious insect pests of American agriculture. Usually several kinds are found together in a locality. Damage from grasshoppers is most severe in the Plains States and mountainous areas of the West. Although the greatest damage to potatoes is foliage injury, certain kinds of grasshoppers are also carriers of spindle tuber and unmottled curly dwarf diseases.

Of the 100 or more kinds of grasshoppers in the United States, the following do the most damage to potatoes:

The **lesser migratory grasshopper,** about 1 inch long, reddish brown with an irregular black patch on the neck, or collar.

The **differential grasshopper,** nearly 1½ inches long, yellow, with chevronlike black stripes on the thighs of the hind legs.

The **two-striped grasshopper,** about 1¼ inches long, greenish yellow, with black or brown markings and two light stripes extending the length of the body.

The **red-legged grasshopper,** about three-fourths inch long, reddish brown above and yellow beneath the body, with the hind legs usually tinged with bright red.

The **clear-winged grasshopper,** about 1 inch long, and yellow to brown, with the outer wings blotched with large brown spots.

Seasonal History and Habits

Most grasshoppers that attack potatoes lay their eggs late in the summer or early in the fall, and these eggs overwinter. Masses of eggs enclosed in pods nearly an inch long are deposited slightly below the surface of the soil. Each pod contains from 10 to 75 eggs, and a single female may deposit from 8 to 20 or more pods. Hard, uncultivated ground is preferred, although eggs are sometimes found along the edges of cultivated fields, in ditch banks, in pastures, and occasionally in hayfields.

The eggs hatch during April, May, or June. The nymphs resemble the adults, but are smaller and without wings. They become adults during the summer or early in the fall. Usually there is but one generation a year.

Control

Grasshoppers may be controlled with dusts, sprays, or baits containing toxaphene. Use 2½ pounds of toxaphene per acre in a dust or 1½ pounds in a spray. A bait should contain 1 pound of toxaphene for each 10 gallons of water and 100 pounds of dry bran. Mix either an emulsion concentrate or a wettable powder containing this insecticide with the water before adding it to the bran. Apply bait at 20 pounds per acre.

Potato fields may be best protected from grasshoppers by locating the young hoppers in uncultivated areas nearby and treating these areas before the pests move into the potato fields.

LEAFHOPPERS

Leafhoppers are small, wedge-shaped insects, which feed mostly on the under sides of leaves. When the leaves are disturbed, the adults fly and the young nymphs scamper for cover, traveling sidewise like crabs.

Several kinds of leafhoppers attack potatoes. The potato leafhopper occurs throughout the eastern half of the United States and has been found in a few States farther west. The intermountain leafhopper is widely distributed throughout the intermountain areas of the Western States. The arid and the western potato leafhoppers infest potatoes in parts of the Southwest. The two causing the most damage are the potato leafhopper and the western potato leafhopper.

Nature of Injury

Adults and nymphs of leafhoppers suck the sap from potato leaves and stems, weakening the plants. This loss of vitality may be very rapid during hot, dry weather.

The potato leafhopper and the western potato leafhopper also introduce into the plant a toxic secretion which causes hopperburn. In affected plants the tips and margins of the leaflets curl upward, turn yellow, and finally become brown and brittle (fig. 11). The feeding and hopperburn together often destroy entire fields of potatoes as if a fire had swept over them (fig. 12). This condition is often

Figure 11.—Potato leaf with curled margins, a typical symptom of hopperburn caused by the potato leafhopper. (Enlarged.)

Figure 12.—Field of early potatoes with foliage destroyed by a heavy infestation of the potato leafhopper.

mistakenly ascribed to the effect of hot, dry weather. Early varieties, such as Triumph and Early Ohio, are most susceptible to hopperburn.

The intermountain leafhopper causes a yellowing of the leaves but not true hopperburn. The clover leafhopper, which is generally distributed throughout the United States, sometimes infests potatoes and spreads two potato virus diseases, yellow dwarf and mosaic. The beet leafhopper, found in the western part of the United States, occasionally transmits the beet curly-top virus to potatoes. The six-spotted leafhopper transmits the aster yellows, or purple-top, disease of potato.

Seasonal History and Habits

The leafhoppers that damage potatoes resemble one another closely in shape and general appearance. A description of one kind will therefore suffice for all.

The adult potato leafhopper is a pale-green, wedge-shaped insect about one-eighth inch long, with conspicuous white blotches on the head and thorax (fig. 13). It lays tiny eggs in the stem or large veins

Figure 13.—Adults of the potato leafhopper. (Enlarged.)

of the leaf. The nymphs are wingless and smaller than the adults, but otherwise resemble them closely.

In the North adults overwinter under leaves, weeds, and trash, appear in April and May to feed on various plants, and later migrate to potatoes. Farther south the adults may remain more or less active throughout the winter.

The life cycle requires from 2 to 6 weeks, depending on the temperature. There are two generations annually in the northern part of the United States; farther south there may be three or four generations.

Control

To control leafhoppers on potatoes apply a DDT spray or dust as recommended for the Colorado potato beetle (p. 14). Arsenicals, cryolite, and rotenone are not effective. Begin spraying or dusting as soon as the first adult leafhoppers appear on potatoes. It is generally necessary to make four to six applications a week to 10 days apart, depending on the severity of the infestation and the spread of hopperburn.

Apply dusts at the rate of 20 pounds per acre when the plants are small, and up to 40 pounds per acre as they grow larger. Use two nozzles to the row and direct the dust upward to the under sides of the leaves.

When applying a spray use three nozzles to the row, so that the entire plants, especially the under sides of the leaves, will be covered. When the plants are small 80 gallons per acre applied with ordinary equipment may be sufficient, but as they grow larger more spray will be needed. As much as 135 gallons per acre may sometimes be required for a thorough job.

Bordeaux mixture, widely used in the Eastern and Midwestern States for the control of certain potato diseases, helps to control leafhoppers. However, it is not very toxic to them, and is of value chiefly as a preventive. It has been reported to cause injury to potato plants in New Mexico. Sulfur will also aid in preventing leafhopper damage, but it should not be applied when the plants are wet, as some varieties of potatoes are susceptible to burning by sulfur.

WIREWORMS [3]

Several kinds of wireworms are major pests of potatoes, whether grown for table use or for seed. Some of the principal wireworm pests of potatoes are the wheat wireworm and eastern field wireworm in the Northeastern and Midwestern States, corn wireworms in the Eastern and Midwestern States, the prairie grain wireworm of the

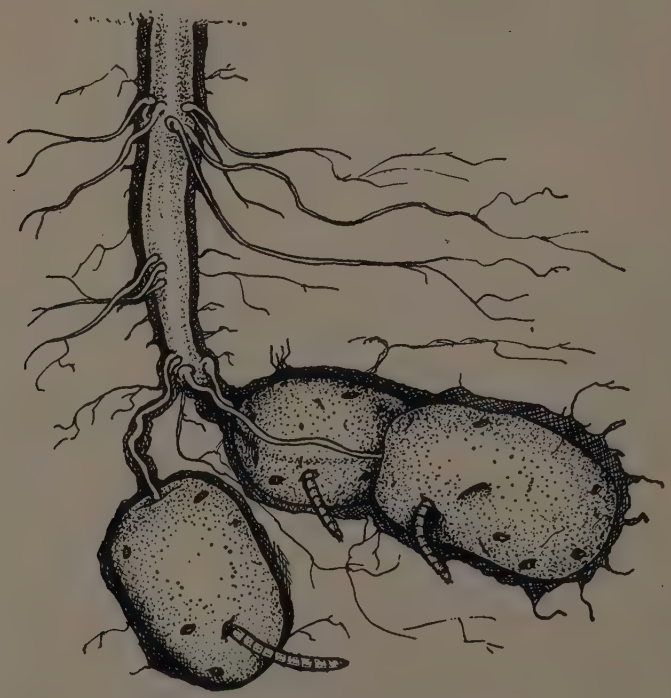

Figure 14.—Wireworms feeding on potato tubers.

[3] This section was prepared by M. C. Lane.

Northwestern States, the Gulf wireworm in the Southern States, and the sugar-beet wireworm and the Pacific Coast wireworm in the Pacific Coast States.

Nature of Injury

At planting time the wireworms often feed on the potato seed pieces and retard or prevent plant development. Sometimes they cause so much damage that the field has to be replanted. Wireworms chew deep pits or holes in the developing tubers (figs. 14 and 15). These holes lower the grade under which the potatoes are sold and often make them unmarketable.

Figure 15.—Potatoes cut to show tunnels caused by wireworms.

Damage by wireworms to seed pieces also affords shelter and feeding entrances for certain fly maggots that spread the blackleg disease of potatoes. The fungus disease known as rhizoctonia, or black scurf, may enter the feeding holes and damage the developing tubers. Damage caused directly or indirectly by wireworms is frequently considered the most important of all tuber injuries.

Seasonal History and Habits

Adults of wireworms are slender, hard-shelled beetles, one-fourth to one-half inch long. The different kinds range in color from reddish brown to black. When placed on their backs, they all snap their bodies and throw themselves in the air with an audible click, and so are called snap or click beetles. In the spring at about planting time they emerge from the soil to mate and then return to deposit their eggs several inches deep in the damp soil. A female usually lays from 100 to 300 eggs. The eggs hatch in a few days to a week or more, and the young larvae, or wireworms, crawl around in the soil, feeding on seeds, roots, stems, and tubers of the growing plants.

The wireworms have hard jointed bodies from ½ to 1 inch long, and are white to yellow, and sometimes dark orange. They do the most damage on the lighter sandy loam types of soil. In hot, dry weather they move downward in the soil. Wireworms have the habit of congregating; up to 50 or more are sometimes found in a single potato or corn hill.

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Wireworms usually live several years before transforming to adults. They remain in the soil, feeding in the upper layers during the spring and summer, and migrating downward to pass the winter. Freezing temperatures do not ordinarily affect them.

Different kinds of wireworms prefer different conditions. For example, the wheat wireworm increases in abundance in fields planted for several years to hay crops, but clean cultivation gradually reduces its numbers. The opposite is true of the Pacific Coast wireworm, which becomes more abundant in fields under intensive cultivation and gradually decreases in fields planted to pasture grasses and alfalfa.

Control

Before planting potatoes it is good insurance to find out how many wireworms there are in different fields, and then select fields with the lowest wireworm populations. Take soil samples over the field with a shovel or soil auger to the depth of 1 foot. If you find more than one wireworm to 1 square foot of soil, it is hazardous to attempt to grow potatoes without applying control measures before planting.

Fumigation With Ethylene Dibromide

Soil fumigation with ethylene dibromide will control wireworms at a cost of about $20 per acre for materials. Best results are obtained in light sandy and loam types of soil, when the temperature is above 40° F. and the soil in suitable condition for plowing. The fumigant can be applied with special tractor-drawn machines or by gravity from a tank attached to the plow.

Use 10 gallons of a 40-percent ethylene dibromide solution per acre. If an 85-percent solution is available, dilute 3 gallons with 7 gallons of petroleum thinner to give the 40-percent solution. Place it 8 inches deep in the soil at 12-inch spacings and cover immediately. Do not plant potatoes within a week after fumigating; allow 2 weeks when the soil temperature is below 50° F.

Use of DDT or Other Insecticides

DDT will control the Pacific Coast wireworm and the sugar-beet wireworm in the irrigated lands of the Western States. In economical dosages DDT kills the larger wireworms very slowly, but it remains in the soil for several years and continues to kill new-brood wireworms as they hatch. Apply DDT at the rate of 10 pounds per acre. Use 20 pounds of 50-percent wettable powder or its equivalent in a water spray or as a dust.

Spray or dust the soil surface and then thoroughly mix the insecticide with the top 6 to 9 inches of soil. A double disk harrow, pulled with a medium-weight tractor, will do this, especially if the land is plowed first. It is important to mix the insecticide thoroughly and deep enough to reach all the wireworms. Merely harrowing it into the soil an inch or two will not give a good kill. Apply in the fall or at least 6 to 8 weeks before planting.

DDT has not proved so satisfactory for the control of the wireworms that occur east of the Rocky Mountains. Lindane and benzene hexachloride are effective but may give the tubers an off-flavor. Therefore, these insecticides should never be used on land where potatoes are to be grown.

Cultural Control

Cultural practices and crop rotations help to prevent wireworm damage to potatoes. Because of the wide variation in the habits of wireworms in different sections of the country and in the crops, climate, and soil, control by cultural practices must be fitted to local conditions.

In the Eastern States potatoes should be planted only on well-drained land, never after red clover or timothy or after fallow. Damage is usually least after some other cultivated crop has been grown for 1 or 2 years or a quick-growing, green manure crop resistant to wireworms, such as buckwheat, has been plowed under. In the Red River Valley the prairie grain wireworm can be starved out by practicing summer fallow at least once in 4 years, and potatoes should never be planted oftener than once in 3 years on the same land.

On the Pacific coast, under irrigated conditions, wireworms can be reduced in numbers by drying the soil during the summer, and by summer plowing where possible. The growing of alfalfa for at least 4 years will often reduce wireworm numbers. Potatoes should be planted after alfalfa. Matured early potatoes should never be left in soil where wireworms can damage them.

INSECTS IMPORTANT IN CERTAIN AREAS OR SEASONS

In addition to the insects that cause widespread damage to potatoes, others may be important pests in certain seasons or areas. Some of them, such as the armyworm and blister beetles, although generally distributed throughout most of the country, may not damage your potatoes for years, but some day they may appear in certain fields in such numbers as to threaten destruction if not controlled. White-fringed beetles are capable of destroying the potato crop, but they occur only in certain sections of the South. Likewise the potato psyllid is destructive in certain western areas such as Colorado and western Nebraska, but does not occur in the East.

ARMYWORMS

The larvae, or caterpillars, of several kinds of moths assume a marching habit when their food supply becomes exhausted, and large numbers often travel together. For this reason they are called armyworms. They have voracious appetites and rapidly consume the tender parts of plants, leaving only the bare stems. Primarily they attack wheat, corn, oats, rye, and grasses, but they may also destroy potatoes, cotton, tobacco, legumes, and many other garden crops.

The true armyworm and the fall armyworm are most generally destructive. The armyworm occurs in most parts of the United States, but is especially destructive in the East. The fall armyworm is found in all States except in the Far West, but is most destructive in the South. The yellow-striped armyworm and the southern armyworm are also occasionally found in potato fields. In the dry-land areas of the West armies of the white-lined sphinx caterpillar may attack potatoes.

Seasonal History and Habits

Destructive outbreaks of the true armyworm may occur when the temperature is normal and the soil moisture slightly higher than normal. In the North outbreaks usually follow mild winters, although cold, backward springs are favorable for the development of some kinds.

The moths are active at night, flying together in large numbers, and swarms of them may be attracted to lights. Flight is usually in the direction of the prevailing wind. The young larvae feed chiefly at night, and their presence may not be noticed until they have exhausted their available food. At this time they begin their march, often by the millions, leaving destruction in their wake.

The moth of the armyworm is about three-fourths inch long and brownish gray with a white spot near the center of each outer wing (fig. 16). The full-grown larva is a smooth caterpillar about 1½

Figure 16.—Moth and larva of the armyworm.

inches long. It is greenish with a very dark stripe along each side of the body and either two dark stripes or a dark band down the back.

In the North the armyworm overwinters as a larva or pupa, but in the South all stages from egg to adult may be present throughout the winter. Usually there are two to three generations each year.

The fall armyworm moth is about three-fourths inch long and grayish white, with a white spot near the tip of each outer wing. The full-grown larva is about 1¼ inches long, practically hairless, and ranges from light tan or green to dark green. Extending down the back are three narrow yellowish-white bands, bordered on each side by a wide dark band and a wide, wavy yellow band splashed with red. On the front of the head is a prominent white inverted Y.

The fall armyworm overwinters in several stages in the South, but is unable to survive the winter in frozen ground in the North. In the spring, swarms of adults fly northward, sometimes covering hundreds of miles in a single flight. By midsummer they may be distributed over most of the northern States. In the North probably only one generation is produced, but in the South there may be as many as five or six generations.

The larvae of the white-lined sphinx may become migratory, leaving Russian-thistle and other weeds to damage potatoes, tomatoes, peas, and crested wheatgrass. The full-grown larva is about 3 inches long and either bright green or black, with yellow head and yellow

spiny horn at the rear of the body. The adults are large night-flying moths. There are probably two generations a year.

Control

Fields of small grains or grasses should be carefully watched for the appearance of armyworms, so that control measures may be taken before they march into the potato fields. The heaviest growth of plants in several parts of each grain field or meadow should be examined early in the morning or late in the afternoon. If the caterpillars are abundant in only a small area, cutting the grain or grass and scattering straw over the surface and burning it will be sufficient. Large areas should be treated by one of the methods described below.

Poison baits give satisfactory control. A bait may be prepared by mixing 1 pound of sodium fluosilicate or paris green or 1½ pounds of calcium arsenate with 25 pounds of flaky wheat bran and moistening with about 3 gallons of water. Broadcast the bait thinly late in the afternoon at 8 to 10 pounds per acre. If the armyworms are nearly full grown and on the march, spread the bait in a swath in front of them.

Dusting or spraying with toxaphene or DDT at the rate of 1½ to 2 pounds of the toxicant per acre will also give good control. These insecticides may be applied in concentrated sprays by airplane.

Vegetation that has been treated with toxaphene or DDT should not be fed to milk animals or to meat animals that are being finished for slaughter.

When armyworms are on the march, a large proportion of them can be destroyed by plowing furrows 8 to 10 inches deep across their line of march and dragging a log through them. The straight side of the furrow should face the caterpillars. If postholes are dug 20 feet apart in the bottom of the furrow, the armyworms will collect in them and can be killed by spraying with kerosene or used crankcase oil.

BLISTER BEETLES

Many kinds of blister beetles, or old-fashioned potato bugs, feed on potato foliage from time to time over much of the United States. The most important kinds are the striped blister beetle, the black blister beetle, the margined blister beetle (fig. 17), the ash-gray blister beetle, and the spotted blister beetle. They feed on many field and truck crops, ornamentals, and weeds from July to September in the North and over a longer period in the South. Most kinds travel in large numbers like an army. Sometimes hungry hordes fly into potato fields, strip the young, tender leaves down to the midrib, and leave as suddenly as they came. They are not a constant pest of potatoes, but occur in destructive numbers occasionally, particularly following the years of grasshopper outbreaks. When swarms of them descend on a field, they may either check the growth of the plants temporarily or cause a serious reduction in yield. They have been known to infect potatoes with the organism of brown rot (bacterial wilt).

Blister beetles range in color from dull red to gray or black; some are striped or spotted and others have a solid color. They also vary in size, but all are long, slender, soft-bodied insects. Their bodies

contain a caustic substance, cantharidin, which causes a blister when one of them is crushed against a person's tender skin—thus the name blister beetle.

The females lay masses of 50 to 300 eggs in cavities in the ground, and the larvae of most kinds feed on grasshopper eggs. The immature forms are therefore beneficial to man; only the adults are harmful.

In the North there is but one generation a year, but in the South some kinds have a partial second generation. The insects hibernate in the immature form, and some kinds may remain in the ground for a year or two before transforming to adults.

Figure 17.—Margined blister beetle feeding on a potato leaf. (Enlarged.)

Control

Because blister beetles appear suddenly and may do considerable damage before they are detected, insecticides are generally applied as an emergency measure after the beetles have attacked a crop. Failure to obtain adequate control usually may be attributed to applying insecticides too sparingly, too late, or without reference to the habits of the beetles.

Apply cryolite dust or a 5-percent DDT or toxaphene dust at about 40 pounds per acre. Direct the dust at the beetles themselves, instead of at the foliage. They clean their bodies by scraping off dirt with their legs and then draw their legs through their mouth parts. Therefore, if the beetles are coated with an insecticide, they ingest much more of it than if only the foliage on which they feed is dusted. Blister beetles usually congregate within small parts of the fields. They are likely to scatter when dusted, unless the dust is directed in such a manner as to drive them to the center of the infested area. For best results apply the dust with a rotary hand duster around the outside edge of the infestation first, and then, while dusting in smaller circles around the area, drive them toward the center.

CUCUMBER BEETLES

Cucumber beetles feed on the foliage of many crops and weeds. The slender white or yellowish larvae of these beetles feed on the underground parts of the plants. In potato tubers they cause holes resembling wireworm damage. Damage is greatest during wet seasons and on lowland. The kinds most destructive to potatoes are the spotted cucumber beetle and the striped cucumber beetle, which are generally distributed east of the Rocky Mountains, and the western spotted cucumber beetle and the western striped cucumber beetle west of the Rocky Mountains.

Cucumber beetles are green or yellowish, marked with black spots or stripes. They are about one-fourth inch long, with narrow bodies tapering forward to a conspicuous collar separating the wing covers from the dark head.

In the North cucumber beetles overwinter in trash and debris and become active early in the spring. In the South they are active throughout the year. Large numbers of these beetles migrate north and south with the seasons, often traveling 500 miles in 3 or 4 days. Females lay their eggs in the soil; they may lay several hundred eggs each. From two to four generations may occur each year, depending on the section of the country.

Figure 18.—Adult moth and larvae of the spotted cutworm.

Control

To protect potatoes from cucumber beetles apply a 3-percent DDT dust at 20 to 30 pounds per acre. Many beetles fly out of fields during the dusting operation. Therefore, begin dusting on the windward side of the field, so that beetles that take wing, as well as those remaining on the plants, will be covered. Applications of dust from airplanes have given some success.

Early plowing and frequent cultivation to prevent growth of weeds before planting a crop help to prevent egg deposition in the soil and thereby reduce damage. Neither the eggs nor the larvae can survive in dry soil.

CUTWORMS

The larvae of many kinds of moths cut off the stalks of potatoes and other tender plants—hence the name "cutworm." The most important kinds are the variegated cutworm, the black cutworm, and the spotted cutworm (fig. 18), which are generally distributed throughout the United States; the glassy cutworm and the dingy cutworm,

which occur throughout the Northern States; and the pale western cutworm, found only in the Western States.

Most cutworms eat only a little of the stem that they have cut off and move on to attack other stems. Consequently, a few may destroy many small plants in one night. The variegated cutworm and the dingy cutworm may climb the plant and eat the foliage; the black cutworm feeds at or just above the surface of the ground; and the pale western cutworm moves entirely under ground and cuts off the plant 1 to 2 inches below the surface. Cutworms occasionally feed on the potato tubers (fig. 19).

Figure 19.—Potatoes damaged by cutworms.

Adults of cutworms are brown or gray moths. They fly at night, sipping the nectar of flowers, and depositing hundreds of eggs on the stems of grasses and weeds or in the soil.

The cutworms, or larvae, are brownish, greenish, or gray, some with faint spots or lines down the back, and nearly hairless. When full-grown they are plump and may be nearly 2 inches long. They have the distinctive habit of curling the body tightly when disturbed. In the daytime they may be found in the soil or beneath trash close to a plant that has been recently cut off. They feed during the cooler part of the day, or at night. Usually they are most numerous in newly plowed grassland, following a rye cover crop, or in spring-flooded bottom lands.

The larvae are active during the summer in the North and throughout the year in some parts of the South. Those hatching late in the summer overwinter as immature larvae. The next spring, when nearly full grown, they severely damage young plants. There may be one to four generations each year, depending on the kind and on the section of the country.

Control

Damage to potatoes by some kinds of cutworms may be avoided by fall plowing and by the rotation of crops so that potatoes do not follow grass or sod.

Most cutworms may be controlled by dusting the fields with 5-percent DDT or 10-percent toxaphene at about 30 pounds per acre. For some cutworms best results can be obtained by working the dust into the top inch of soil.

Poison bait is also usually effective. Prepare the bait by mixing 1 pound of either sodium fluosilicate or paris green with 25 pounds of dry wheat bran and moistening with about 3 gallons of water. Broadcast the bait evenly and thinly over the infested area at 15 to 20 pounds per acre, preferably late in the afternoon. Some of the cutworms may be killed the first night, but it usually takes 2 or 3 nights to kill most of them. Repeat the application if necessary.

EUROPEAN CORN BORER

The European corn borer is one of the most destructive pests ever to invade this country. Although corn is its favored host and receives by far the greatest damage, the borer also infests potatoes and many other vegetables, as well as flowers, field crops, and weeds. It is generally distributed from South Carolina northward to Maine, and westward to North Dakota, Colorado, and Oklahoma.

The adult female is a pale-yellow to light-brown moth with a robust body about one-half inch long. There are usually two dark zigzag lines on the wings. The male moth is slightly smaller and darker than the female.

The female lays her eggs in masses of 15 or more on the under side of the leaves. During her life a female lays an average of 400 eggs. The eggs are nearly white when first laid, but turn pale yellow, and then darker just before hatching.

The full-grown larva is about an inch long, with a dark-brown or black head. The upper surface of the body may be brown or pink, with a row of dark-brown spots on each segment, and several dark lines extending lengthwise of the body. The under side is flesh-colored and without markings.

The insect overwinters as a full-grown larva in the stalks of corn and other crop plants and weeds. In the spring the larvae transform into brown pupae about one-half inch long and later emerge as adults.

The insect spreads in two ways. The adults may fly long distances, or the larvae may be carried in cornstalks or other plants by floodwaters, tidewaters, or other means.

There may be from one to three generations of the corn borer in different parts of the country.

Control

The European corn borer on potato plants may be controlled by dusting with 5-percent DDT or spraying with DDT weekly during the egg-laying period as for aphids (p. 12).

FALSE CHINCH BUG

The false chinch bug frequently injures potato plants. It occurs throughout the United States, but rarely in damaging numbers except in the dry areas of the West. There the bugs increase to enormous numbers during the spring and early part of the summer, chiefly on weeds growing on abandoned land. When the weeds dry up, the adults and nymphs move to potatoes and other crops, where they may do severe damage in a day or two. The numerous punctures made by these bugs while feeding cause the leaves to wilt and die, and the plants may be stunted or killed.

The adults are about one-eighth inch long, narrow-bodied, and grayish brown. Both adults and nymphs overwinter in grass or litter and emerge early in the spring. Crescent-shaped pink eggs are laid in the soil, on foliage of low-growing plants, and even in the blossoms. The eggs hatch after about 4 days, and the dull-gray or reddish-brown nymphs feed for about 3 weeks before changing to adults. In the North there are three to five generations in a year.

Control

When false chinch bugs are found in large numbers on weeds and grasses, spraying the plants with undiluted kerosene will kill both the insects and the plants. The weeds also may be dusted with a 1:3 mixture of powdered calcium cyanide and talc, but this dust should not be applied to the foliage of cultivated crops. A nicotine dust or spray will give moderate control. As a dust use nicotine sulfate diluted with lime to contain 3 percent of nicotine. To prepare a spray use 1½ pints of nicotine sulfate (containing 40 percent of nicotine) and 5 or 6 pounds of fish-oil soap or cheap laundry soap in 100 gallons of water. Apply this amount of spray to 1 acre.

The burning of field litter and weeds in the fall and the destruction of weeds during the spring assist in keeping this insect in check.

GARDEN CENTIPEDE

The garden centipede, a symphylid, which is not a true insect, is a generally distributed pest of many crops. It shears off the fine root hairs of potato plants, causing the plants to become stunted and the yields reduced. In the East it is a common greenhouse pest.

Adults of the garden centipede are white, fragile creatures, which run with a slithering movement. They may be from one-fifth to three-eighths inch long and have very narrow bodies and 12 pairs of short legs. A pair of long white antennae protrude forward from the head. The young are more hairy than the adults and have fewer legs and shorter antennae.

Early in the spring the female lays masses of 4 to 20 eggs and guards them closely until they hatch about 10 days later. The centipedes become mature within 45 to 60 days. They are most numerous in May, June, and July. When the ground surface becomes too hot and dry for them, they move into the cooler subsoil. Prolonged drought, summer fallow, or intensive dry cultivation does not appreciably reduce the population, and the centipedes may remain alive for many months.

Control

Where fields are level and irrigation water is available, continuous submergence under 6 inches of water for 2 weeks during the summer or for a month during the winter will rid the soil of centipedes for about 2 years.

PLANT BUGS

Various kinds of plant bugs attack the foliage of many plants and sometimes damage potatoes. While feeding, these bugs pierce the stems, and it is believed that some of them inject a poisonous substance which affects the plant's growth. The immediate evidence of injury to potatoes is a wilting of tender new growth, but leaflets or even entire leaves may be killed. The tarnished plant bug and closely related kinds also transmit a disease known as spindle tuber, which causes misshaped tubers.

The tarnished plant bug is the most widely distributed of these bugs and also the most injurious. The western plant bug (cotton dauber or legume bug) and the pale plant bug are also important in many Western States. All three kinds often occur in enormous numbers on alfalfa, clover, and other crops and migrate to potatoes when hay is cut or other host plants mature.

The adults of these bugs are approximately one-fourth inch long and one-eighth inch wide, flat and oval, with a small triangular area at the base of the wings. They may be brown, yellow, or mahogany, usually with white or black blotches. Adults of the several kinds usually differ slightly as to color, but this difference alone is unreliable for determining the kind.

Adults overwinter in trash and appear early in the spring. Eggs are deposited in stems of growing plants and hatch in about 10 days. The nymphs are yellowish or bluish green. A few nymphs may appear in May, but they become most abundant in June or July. From 3 to 5 weeks are required to complete the life cycle, and there may be from two to five generations each year.

The four-lined plant bug breeds chiefly on herbaceous plants. It is a minor pest of potatoes, where it makes closely grouped feeding punctures in the leaves. The adults are about one-fourth inch long and half as wide. They are greenish yellow to dark green, with four black stripes extending two-thirds of the way down the back. They may appear on potatoes about the middle of June, and probably there is but one generation a year.

The rapid plant bug is a very active bug about one-fourth inch long, brown except for a narrow yellow border, and with long, slender, light-colored legs. It is a common pest of cotton and occasionally feeds on potatoes in the Mississippi Valley. This bug causes a wilting of the leaves and growing tips. The adults appear in July and lay their eggs singly in potato stalks. In about 2 weeks the eggs hatch into greenish nymphs with red markings. A second generation appears late in July and early in August. It is believed that the adults hibernate.

Another group of plant bugs of similar habits are the fleahoppers. These small, soft-bodied insects resemble flea beetles both in form

and in their habit of jumping when disturbed. Two kinds of fleahoppers are minor pests of potatoes.

The garden fleahopper occasionally becomes abundant on potatoes in the Northern States. It feeds on the under sides of the leaves, causing white patches of dead tissue to form, and if the insects are numerous the plants may become stunted or even be killed The adult is about one-tenth inch long, shiny black with very fine white hairs, and has pale-yellow areas on the legs and antennae. The insect winters in the adult stage, and in the spring deposits eggs in feeding punctures. The greenish nymphs appear early in the spring. Five generations have been recorded in the South.

The cotton fleahopper occasionally attacks potatoes in the Southern States. The feeding habits and damage are similar to those of the garden fleahopper. Cotton fleahopper adults are about one-eighth inch long, rather elongate and flattened, and pale green, with a sparse covering of fine black hairs. The insects winter as eggs, which the females deposit in the stems of weeds. There are several generations in a year.

Control

For the control of plant bugs apply DDT as for the control of the Colorado potato beetle (p. 14).

Pyrethrum dust containing 0.2 percent of pyrethrins and 30 to 50 percent of fine dusting sulfur will give rapid kill of most of the bugs, but it will not have the residual effect of DDT; therefore more than one application will probably be required.

Bordeaux sprays used for control of potato diseases will repel these bugs.

A general clean-up of weeds and plant litter in the fall prevents overwintering of the bugs near fields in which susceptible crops may be grown the following year. Potato fields should be as far as possible from alfalfa and clover fields. After each cutting of alfalfa or clover, potato fields should be examined to determine the need for applying dusts.

POTATO PSYLLID [4]

The potato psyllid is a very destructive pest of potatoes in Colorado, Nebraska, and New Mexico. It also occurs in most other Western States except Oregon and Washington. This tiny insect injects into the plants a substance that causes a curling and yellowing of the leaves known as psyllid yellows.

The adult psyllid (fig. 20) is a narrow insect about one-tenth inch long. The wings fold together rooflike above the body. A broad white band extends across the middle of the gray body and an inverted white Y occurs at the tip of the abdomen. The legs are fitted for jumping, and the adults take flight on the least disturbance and consequently are seldom seen on the plants.

The eggs are spindle-shaped and light yellow to orange and are suspended from the leaves on short stalks. They hatch in 3 to 8 days into young nymphs which are flat, scalelike, and light yellow or green.

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[4] This section was prepared by R. L. Wallis.

These nymphs secrete a white wax, which may often be seen on the leaves and on the ground. They are inactive and usually feed on the under sides of the leaves. There may be as many as 10 generations during a season in some parts of the Western States.

Psyllids develop during the winter in Texas and New Mexico on weeds of the nightshade family, and move northward in the spring as food plants become available. They appear in eastern Colorado during the first half of May and in Utah early in June.

Figure 20.—Adult, nymphs, and egg of the potato psyllid. (Enlarged.)

Large psyllid populations do not develop when temperatures are high. In the Plains areas, where potatoes are grown during hot weather, the damage is likely to be much less than at high elevations where summer temperatures are lower.

Psyllid yellows is caused only by the feeding of psyllid nymphs. The first symptoms in the potato are an upward curling of the basal portion of the terminal leaves and a change in color from the normal green to light green or yellow. As the disease advances, the curling extends to the tip of the leaf and the curled portion becomes reddish purple. The leaves feel harsh or leathery, the plant becomes stunted, and in advanced stages of the disease the plant may turn brown and die. The growth of the tubers is materially retarded. The set of tubers is increased, but they are too small to be marketable. Aerial tubers may also form in the leaf axils.

Control

DDT will control the potato psyllid if it is applied at the right time in the right manner. Apply a 5-percent dust at 25 to 35 pounds per acre or a spray containing 2 pounds of a 50-percent wettable powder in 100 to 125 gallons of water per acre.

Best results can be obtained by applying the insecticides when one or more adult psyllids can be caught in 100 sweeps of an insect net. Sweep the plants briskly with the net opening two-thirds below the tops of the plants. Take four or five 100-sweep samples in each field every 10 to 14 days. One adult psyllid per 100 sweeps can cause a loss of about 10 bushels of potatoes per acre. If the psyllid population is not determined, make four or five applications 10 to 14 days apart, beginning when the plants are 6 inches high.

In years of light infestations—a maximum of two or three psyllids per 100 sweeps—two or three applications will be sufficient, but in epidemic years five applications will be necessary to provide good control.

Apply the insecticide to the lower portion of the plants and on the under sides of the leaves. Use a duster with two nozzles to the row, directed upward from just above the ground level. For applying sprays a power sprayer is essential, in order to maintain a pressure of at least 350 pounds per square inch. Use one nozzle on each side of the row near the ground level directed upward at an angle of 45° and a third directed downward from above the plants. Turn one of the side nozzles to spray slightly in front of the other.

Give particular attention to potatoes in home gardens. As these potatoes are usually planted early, they are highly susceptible to psyllid attack. If neglected the psyllids are able to increase to large numbers and become a source of infestation in commercial plantings.

Do not leave piles of cull potatoes where they will sprout and provide a breeding place for the potato psyllid. Destroy cull potatoes or spread them out in the sun to rot.

POTATO SCAB GNAT

The larvae of several fungus gnats attack the underground parts of the potato plant. These insects breed in decaying plant materials and are attracted to wounds in potato tubers that have been caused by other insects or by disease organisms.

The potato scab gnat is the most important of these gnats in the Northeastern and North Central States and is rather generally distributed. The adults, fragile dark-brown flies, are usually concealed in the soil. Eggs are deposited on the potato seed pieces at planting time or in the soil throughout the season. The minute white maggots, or larvae, attack the seed pieces, the growing tubers, or the underground parts of the stems. The wounds in which the larvae feed are fairly deep, irregular in outline, and filled with a brown, granular refuse. If much of the seed piece is destroyed, the plant is weakened and the yield is reduced. Scab gnat injury to the developing tubers resembles that caused by the common scab disease of potato, with which it is associated late in the season. Larvae entering scab lesions already formed may continue to feed in the sound flesh below the discolored area after harvest. The tubers thus infested deteriorate during storage.

Control

To kill scab gnat eggs attached to potato seed pieces, dip the seed in corrosive sublimate or hot formalin solution, using the formulas and precautions recommended for treating seed pieces for the control of certain disease organisms.[5] As the insect overwinters in the soil, treatment of the seed may not protect the crop throughout the season.

Potatoes grown in acid soils (pH about 5) are seldom affected by the scab gnat. Measures that keep the soil acid will therefore protect the potatoes.

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[5] Farmers' Bulletin No. 1881, Potato Diseases and Their Control, revised in 1948.

Measures that prevent the heating and sweating of the tubers in bins also prevent the spread of tuber rots and secondary infection from scab gnat or other insects.

Rotation of potatoes with less susceptible crops is recommended.

POTATO TUBERWORM

The potato tuberworm attacks potato foliage, and also the tubers, both before they are dug and when they are in storage. The damage (fig. 21) to the tubers, especially those in storage, may greatly reduce

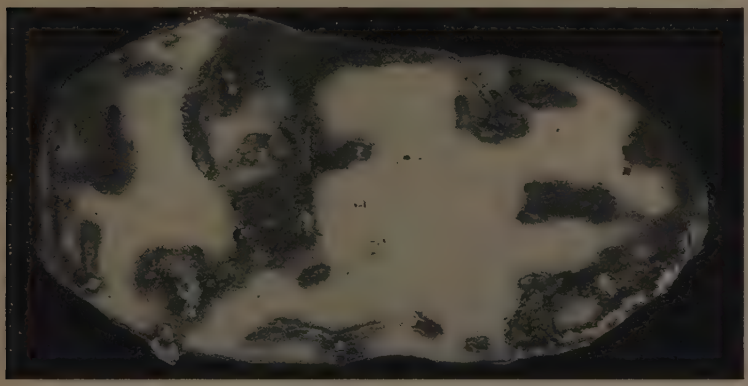

Figure 21.—Half of a potato showing tunnels caused by the potato tuberworm.

the market value of the crop. This insect is spread over wide areas of the country through the shipment of infested potatoes. It has recently been found in 25 States extending from the Atlantic to the Pacific coast. Besides potato it attacks tomato, eggplant, and other plants of the nightshade family.

The adult of the potato tuberworm is a gray moth not over one-fourth inch long, with dark-brown or black markings on the wings. It is seldom seen, because it hides during the day, becoming active only at night.

The female lays from 150 to 200 tiny eggs on the under sides of potato leaves or in the eyes of the tuber if any part of it is exposed above ground. Eggs may be laid on the tubers at harvesttime if they are left on top of the ground overnight. The life cycle may be as short as 2 weeks in summer or as long as 7 months in winter. In the field there are five or six generations a year in the South, but probably not more than two or three in the North. In warm storage this insect may continue the life cycle all winter; in the field it overwinters as a larva or pupa in the soil.

The full-grown larva is about one-half inch long. The head is brown, and the body is pinkish or white, with a wide reddish-purple band down the back.

On potato foliage the larvae join tips of two or three leaflets together with a silky web and feed in this protected location. They may also tunnel in the midrib of the leaf and in the stem of the plant. In the tuber they may burrow just under the skin or tunnel into the flesh.

Control

Preventive measures will usually control the potato tuberworm in the United States. One method of preventing infestations is to plant seed pieces that are not infested. Cultivate the soil to the plants so that the tubers will not be exposed to egg-laying moths. At digging time do not leave the tubers in the field overnight, and do not cover piles of dug tubers with potato plants. Destroy cull potatoes. Leaving them piled up, either in storage or in the open, is a sure means of increasing the tuberworm population.

To kill tuberworms infesting potato foliage, make one or two applications of a DDT dust or spray. On 1 acre use 20 to 35 pounds of a 3-percent dust or a spray containing 2 pounds of 50-percent wettable powder in 100 gallons of water.

After the potatoes have been harvested, store them in clean, uninfested places. In warm weather all outside openings of storage places should be screened to keep out moths. Recently the treatment of burlap potato bags with DDT has given good control of the tuberworm. The bags may be either dipped in or sprayed with a solution of 2 or 3 percent of DDT in xylene. Bags so treated protect uninfested potatoes, and if they are already infested with larvae, the adult moths will be killed soon after they emerge. One treatment is effective for many months. Some tuberworm control can be obtained by spraying the storage area with the DDT-xylene solution just before potatoes are stored.

To protect tubers intended for seed dust them with a 2-percent DDT dust.

If tuberworms in stored potatoes are not discovered early, fumigation may be necessary to prevent a total loss.

If a vacuum fumigator is available, choice seed or table stock can be treated with methyl bromide. A dosage of 2½ pounds per 1,000 cubic feet for 90 minutes at 70° F. or above is effective. Special fumigation chambers and special instructions are necessary for the use of methyl bromide, and information regarding them can be obtained from the Bureau of Entomology and Plant Quarantine.

CAUTION.—When working with methyl bromide, use a gas mask provided with a canister that will absorb the gas. Do not allow methyl bromide to come in contact with the skin. Store the containers in a cool, well-ventilated place outside inhabited buildings. The gas is practically odorless, but you can readily detect dangerous concentrations of it by a halide leak detector or a lamp devised for the purpose.

SEED-CORN MAGGOT

The seed-corn maggot is the most destructive of several maggots that occasionally attack potato seed pieces (fig. 22). It occurs in most of the United States and is chiefly a pest of sprouting seeds such as corn, beans, and peas. Sometimes in limited areas heavy infestations in potato fields make it necessary to replant them.

These dirty-looking, yellowish-white maggots are about one-fourth inch long when full grown. They do their greatest damage in cool, wet seasons and in soils containing large amounts of decaying vegetation or organic fertilizer that has not been thoroughly worked in.

They attack the potato only through cut, injured, or diseased surfaces. The maggots spread the bacteria that cause the blackleg disease of potatoes.

The adult flies are about one-fifth inch long and greenish or grayish to nearly black. They emerge in the spring and deposit eggs either in soil where there is an abundance of decaying organic matter or directly on the seed or plant. In the central part of the country there are three to five generations a year.

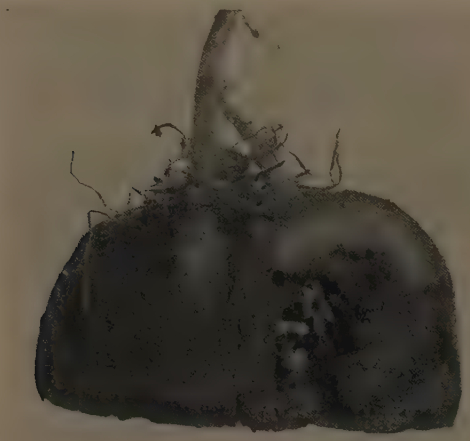

Figure 22.—Seed-corn maggots feeding within a potato seed piece, a part of which has been cut away to show them.

Control

The best way to prevent the seed-corn maggot from injuring potatoes is to plant only well-healed seed pieces. Cut the potatoes 10 days or more before planting them, so that a protective covering of scar tissue can form over the cut surfaces. To insure healing, first treat the potatoes with a chemical to destroy surface-borne disease organisms, and then dry them. Cut them with a sharp thin-bladed knife to insure clean-cut surfaces, away from bright sunlight. You may store cut seed in baskets, crates, barrels, or sacks, but disinfect the containers and the walls and floor of the storage space. Store the cut seed in a fairly airtight room at a temperature of about 60° F. Wet the floor or hang up clean wet sacks on the walls daily to keep the humidity high. Pour the seed pieces from one container to another 24 hours after they have been cut, and again in 48 hours.

Under these conditions cut seed pieces can be held safely for 10 days. If necessary to hold them longer, lower the temperature to about 40° F. to retard sprouting. Two or three days before planting remove them to an airy place to allow the cut surfaces to dry out and toughen; then handle them carefully so as not to break the newly formed protective covering.

STALK BORERS

The larvae of several insects bore into the stalks of potato, corn, and many other plants, causing the leaves to wilt and frequently a stem or the entire plant to die. When abundant, the larvae may seriously injure or even destroy entire fields of potatoes. Unfortunately, the presence of the borers usually is not recognized until they have done much damage.

One species, known as the stalk borer, is generally distributed throughout the United States east of the Rocky Mountains. The adult is a moth having mouse-colored wings marked with white. Eggs are laid on various weeds, particularly ragweed, where they remain during the winter. In the spring the eggs hatch, and the borers first attack weeds and later migrate to potatoes and other crops. There is but one generation a year.

The young larvae are slender, naked, soft-skinned caterpillars, brownish with five whitish longitudinal stripes. The two stripes on each side of the body are broken in the middle and give the larvae the appearance of being injured. On mature larvae the stripes have faded out and the body is dark gray. These larvae are nearly 2 inches long.

The larvae are more destructive in fields left in weeds during the fall and winter than in those where clean cultivation is practiced. Potatoes along the edges of a field close to fences and uncultivated areas are most likely to be damaged. The larvae bore into the stems of one plant, feed for a short time, and then leave to attack another plant.

Another species, known as the potato stalk borer, is present in most sections of the country. The larvae eat the inside of the stems, killing the plants. When abundant they may destroy entire fields of potatoes.

The adult is a snout beetle about one-sixth inch long, bluish gray with a black head and three black spots at the base of the wing covers. There is a single generation a year.

The adults overwinter in the odd stalks and emerge in the spring to deposit eggs on stems of potato or other host plants. The larvae are one-fourth to one-half inch long, and yellowish with pale-brown heads.

A similar insect, the tobacco stalk borer, attacks potatoes in Arizona and southern California.

Control

To control all stalk borers infesting potatoes, destroy large-stemmed weeds, such as giant ragweed, jimsonweed, horsenettle, and groundcherry, in and near potato fields, and after harvest burn the potato plants or plow them under. In plowing under be sure to cover the vines completely with soil.

VEGETABLE WEEVILS

The vegetable weevil, a snout beetle accidently introduced into the United States, has become increasingly important in the Southern States and in California. It attacks potatoes and many other vegetable crops, as well as weeds. Both adults and larvae feed princi-

pally at night, first on the buds of potatoes, thereby stunting the plants, and later on the leaves, often stripping the plants. They may even cut off the stems of young potato plants at ground level, as do cutworms.

The adult weevil is about three-eighths inch long, dull grayish brown with a pale-gray V near the tip of each wing cover. In common with many weevils, the adults have the habit of feigning death when disturbed. They fall on their backs, draw in the antennae and legs, and remain motionless for several minutes. This habit and the grayish-brown color make them difficult to see on the ground. Adults live for a year or two, but they hide and are inactive during the summer. Late in the fall they deposit eggs on the plants or the soil nearby.

The full-grown larva is greenish, about one-half inch long, slender, and strongly convex. The life cycle ranges from a little over a month to nearly 4 months. There is but one generation a year.

In the South the banded vegetable weevil may be found associated with the vegetable weevil. The adults of the banded kind are a lighter brown, with a light-gray band across the wing covers.

Control

To protect potato plants from vegetable weevils dust or spray them with an arsenical, cryolite, or DDT. If you prefer a dust, use undiluted calcium arsenate, 3-percent DDT, or 50-percent cryolite. Apply about 20 pounds per acre on light foliage and as much as 35 pounds on heavy foliage. Apply cryolite dust only when the foliage is dry. If you wish to use a spray, add 3 pounds of acid lead arsenate or 6 pounds of calcium arsenate or cryolite to 100 gallons of water and apply at 75 to 100 gallons per acre.

Weevils likely to attack future plantings of potatoes may be greatly reduced in numbers by dusting, spraying, or burning crop remnants and weeds that would otherwise provide shelter and food. Cultivation during the fall or winter kills many of the insects while they are in the soil. Do not continue to plant susceptible crops in the same field.

WHITEFLIES

In certain sections of the country whiteflies may occasionally become numerous on potato plants, especially during a long period of dry weather. There are several kinds of these tiny insects. The greenhouse whitefly and the iris whitefly are most likely to be found on potato. The adults usually fly away at one's approach. They lay eggs on leaves of their hosts. The nymphs resemble small scale insects or potato psyllid nymphs. They attach themselves to the under sides of the leaves and feed on the plant sap.

Control

Whitefly infestations on potatoes grown out of doors are not usually serious enough to require treatment. They may be controlled, however, by applying an emulsion containing 1 or 2 percent of highly refined light summer oil. Better results can be obtained by adding 1 pint of nicotine sulfate (nicotine 40 percent) or 2 pints of a pyre-

thrum concentrate per 100 gallons of this emulsion. The spray should be forcibly applied to the under sides of the leaves, where the nymphs feed.

WHITE GRUBS

Widely distributed over the United States, many kinds of white grubs, the larvae of May beetles, feed on the underground parts of nearly all cultivated crops. In potatoes they eat out large, shallow, circular holes (fig. 23). The affected plants do not reveal the injury.

Figure 23.—White grub in the cavity it has eaten in a potato. (Enlarged.)

A heavy infestation of grubs may damage a crop severely before the grower realizes their presence. It is important, therefore, to know whether a field is infested before it is planted to potatoes.

Seasonal History and Habits

The adult beetles are one-half to seven-eighths inch or more long and light to dark brown, with oval, rounded bodies (fig. 24). They emerge from the ground late in the spring and fly clumsily about early in the evenings of May or June, buzzing and scrambling about window screens or against light bulbs. They feed at night on leaves of trees. One species, which occurs in the South, is wingless and crawls from field to field. Females lay pearly-white eggs below the surface of the ground, most commonly in sod or grassland. Each female lays from 25 to 70 or more eggs.

The full-grown larvae are soft-bodied grubs three-fourths to 1 inch long, with brown heads, whitish curved bodies, six prominent legs,

and large abdomens (fig. 25). The larvae of most kinds develop in the ground, where they feed on decaying vegetation and the underground parts of the plants.

In the Northern States most kinds of May beetles take 3 years to complete a generation, and a few in the extreme North require 4 years. Farther south some kinds require only 2 years, or even a single year. In northern areas some May beetles will be present each spring, but they will be most abundant every third year, especially in sections populated by kinds having a 3-year life cycle.

Figure 24.—May beetle, or adult of a white grub. (Enlarged.)

Control

Do not plant potatoes on land known to be infested with white grubs. If you suspect that a field is infested, examine the soil to a depth of several inches.

Figure 25.—White grubs uncovered from sod where they were feeding. (Enlarged.)

Damage to potatoes can be largely avoided by proper crop rotation. One suited to some sections of the country is oats or barley followed by clover and then potatoes. There should be a minimum acreage in small grains and a maximum in some deep-rooted legume, such as clover or alfalfa, during the peak of May beetle flight. Ordinarily the beetles do not deposit many eggs in pure stands of clover or in clean-cultivated land planted to row crops except sugar beets.

White grub populations in pasture land can be greatly reduced without plowing or destroying the grasses by establishing a good stand of a dry-weather legume, such as biennial white sweetclover.

Pasturing hogs on grub-infested land will reduce the infestation. Chickens will also eat many grubs if allowed to run on the land during plowing.

A poisoned bait is effective against the wingless May beetles, which crawl from field to field. To prepare such a bait mix 20 pounds of dry wheat bran with 1 pound of paris green and add 3 ground lemons and 1 quart of corn sirup. Water may also be added if desired. Broadcast this bait early in the evening, at the rate of 7 to 10 pounds per acre.

Another method is to trap the beetles by plowing deep furrows across their paths of march. Smooth the bottoms of the furrows, but leave the sides loose and dig post holes about 15 to 20 feet apart in them. The trapped beetles may be killed with kerosene or with a heavy stick.

WHITE-FRINGED BEETLES

White-fringed beetles feed on a large number of plants, especially potato (fig. 27). They were first discovered in this country in Florida in 1936, and by the end of 1951 they had been found in eight southern States from Louisiana and Florida to North Carolina and Tennessee.

The adult beetles (fig. 26) are approximately one-half inch long and one-sixth inch across the body, dark gray with a lighter band along the margins of the wing covers. There are no males; the females lay fertile eggs in masses of 15 to 25. The eggs are usually deposited at the point of contact between soil and such objects as sticks, gravel, and plant stems. Generally there is a single generation a year. Most of the insect's life is spent in the larval stage in the soil.

Figure 26.—Adult white-fringed beetle. (Enlarged.)

The larvae, or grubs, feed on the potato seed pieces, the stems and roots of the young plants, and the tubers (fig. 28). When present they are so numerous that they may almost completely destroy the crop. The full-grown larvae are about one-half inch long, and are yellowish white, fleshy, curved, and legless.

Figure 27.—Potato field with plants destroyed by white-fringed beetles.

Figure 28.—White-fringed beetle larvae feeding in potatoes.

Control

White-fringed beetle larvae may be controlled by mixing DDT thoroughly with the soil to a depth of 3 or 4 inches. Apply 10 pounds of actual DDT per acre in either a dust or a spray. A 5-percent DDT dust applied to the foliage at 12 to 15 pounds per acre will kill the adults that are feeding above the ground. Treat fence rows, ditch banks, and terraces, as well as the potato foliage, taking care not to let the insecticide get onto any foliage that is to be eaten by man or livestock.

Cultural methods of control include rotation of susceptible legume crops with grasses, including corn and small grains, and thorough disking of the soil in June and July to kill the insects while they are transforming from larvae to adults.

PESTS THAT OCCASIONALLY ATTACK POTATOES

CARROT BEETLE

The carrot beetle is a broad, stout-legged, reddish-brown insect about one-half inch long. Eggs are laid in the soil. The larvae resemble common white grubs, being curved and white, often with a bluish tinge. When full-grown they are over an inch long. Both adults and larvae feed on the roots of potato, and the adults also attack the foliage. This insect is distributed over the United States except the most northern States. There is but one generation a year. No control measures have been developed.

CATERPILLARS

Several caterpillars that feed on a large number of plants occasionally damage potatoes. Among them are the corn earworm, the yellow woolly bear, the zebra caterpillar, the garden webworm, the beet webworm, the cabbage looper, the tomato hornworm, and the tobacco hornworm. For control of caterpillars apply cryolite, an arsenical, or DDT as recommended for the Colorado potato beetle (p. 14). When hornworms are present, use 10-percent toxaphene dust. They are easily recognized by the conspicuous horn at the rear end of the body.

EARWIGS

Earwigs resemble beetles, but have a pair of prominent forceps at the rear of the body. There are seven or more kinds in the United States, ranging from ¼ to 1 inch long. The European earwig is most generally distributed, being most common in the northern coastal States. The earwig is a garden, fruit, and household pest in both the adult and nymphal stages. The adult is about one-half inch long, and of various shades of brown. Earwigs hide during the day and come out to feed at night. The poisoned bait recommended for grasshoppers, cutworms, or the armyworm will control earwigs.

EGGPLANT TORTOISE BEETLE

The eggplant tortoise beetle is about one-fourth inch long, dull

green, with its head hidden from above. The pale-green, flat larvae often match the color of the leaves so closely that they are not seen. Both adults and larvae riddle the leaves with small holes and may kill the foliage. The insect is confined largely to the Southern and Southwestern States. It passes the winter in the adult stage. There are several generations a year. For control apply arsenicals as for the Colorado potato beetle (p. 14).

LEAF MINERS

The tiny maggots of one or more small flies occasionally attack potato leaves. They make long winding mines under the surface of the leaf. These insects occur throughout most of the United States but are most prevalent in semitropical regions. No satisfactory method of control on potatoes has been developed. The application of parathion as for aphids should be effective.

MEALYBUGS

Four kinds of mealybugs occasionally attack potatoes—the grape mealybug, the citrus mealybug, the apple mealybug, and the solanum mealybug. In Oklahoma, Nebraska, and Florida they feed on the roots or stored tubers, but in California they may infest any part of the plant. Mealybugs are oval, scalelike, soft-bodied insects approximately one-eighth inch long. When first hatched they are yellowish, but they soon become covered with a powdery wax, which collects in the form of rods, or tails, as growth proceeds. Mealybugs infesting stored potato tubers may be killed by fumigating with calcium cyanide at the rate of 2 ounces to each 100 cubic feet of space in a tight chamber at 60°–70° F.

MILLIPEDES

Millipedes are occasionally found packed within the tubers at harvesttime. These wormlike animals are grayish-brown, ¾ to 1¼ inches long, with many legs. They are widely distributed. They enter the tubers through injuries caused by slugs, insects, or the potato scab disease; therefore, the damage is greatest near harvesttime. Cultural methods of control and soil treatments for scab disease and scab gnat help to reduce damage by millipedes. The poisoned bait recommended for cutworms or armyworms is effective.

MITES

In dry weather potatoes in the Northwest may be attacked by several kinds of mites, especially the two-spotted spider mite. They cause small wilted areas on the leaves, which turn brown and die. Fields near alfalfa plantings are most likely to become infested. These mites are so small that it is difficult to see them without the aid of a lens. They range from pale yellow or green to orange and red. Mites are controlled with 0.5-percent parathion dust. Sulfur dust may prevent an infestation from developing.

MOLE CRICKETS

Mole crickets occasionally feed on the roots, stems, and tubers (fig. 29) of the potato. There are several kinds of mole crickets—the southern mole cricket, the changa, the short-winged mole cricket, and the northern mole cricket. They are distributed throughout the Southern States from North Carolina to Texas, and one or more kinds can be found as far north as Nebraska, Indiana, and even Massachusetts.

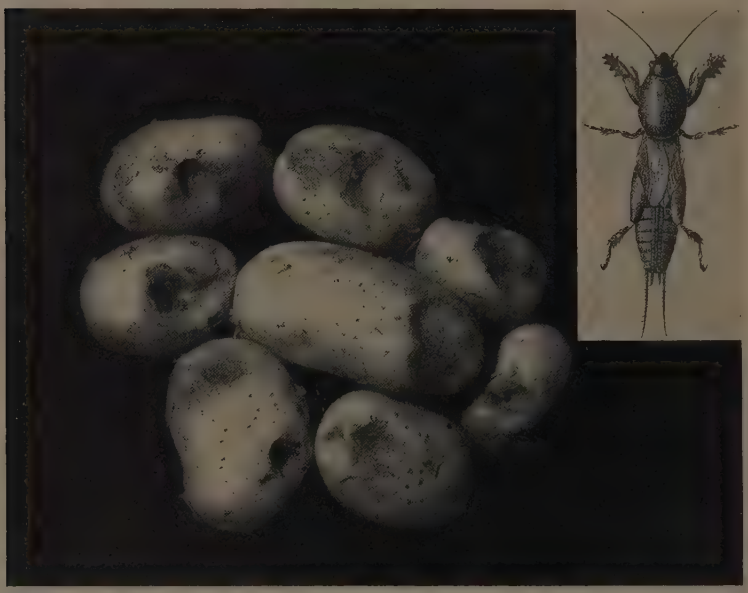

Figure 29.—Potatoes damaged by mole crickets. Insert, adult mole cricket. (Enlarged.)

Mole crickets have short, stout front legs and shovel-like feet adapted to digging, resembling moles in this respect. They are about 1½ inches long, and range from light velvety brown to blackish in color.

The most practical method of controlling mole crickets in potato fields is to use poisoned bait. Mix 1 pound of sodium fluosilicate with 10 pounds of dry bran and add just enough water to moisten and still have the bait spread in individual flakes. Scatter the bait late in the evening, as mole crickets feed on the surface of the soil at night.

SHIELD-SHAPED BUGS

A number of large shield-shaped bugs occasionally attack potato plants. Several stink bugs, the leaf-footed bug, and the harlequin bug belong to this group. They suck the juice from the plants, causing the leaves to wilt and sometimes to die. Damage by the Say stink bug in some of the Rocky Mountain States is known as big-bug blight,

and looks very much like psyllid yellows. The southern green stink bug, the leaf-footed bug, and the harlequin bug occur in the South. These bugs may be controlled with DDT as applied for the Colorado potato beetle (p. 14).

SLUGS

Slugs feed on potato foliage at night and leave a glistening, slimy trail. They also feed on the tubers, leaving cavities recognized by the uneaten potato skin which remains hanging over them. Slugs are not insects, but slimy, legless, soft-bodied creatures from ½ to 8 inches long. They are widely distributed. Common ones are the gray garden slug, the spotted garden slug (fig. 30), and the tawny garden slug.

Figure 30.—Spotted garden slug.

Commercial poisoned baits containing metaldehyde give good control. A satisfactory bait can be made by mixing one-quarter pound of metaldehyde and one-half pound of sodium fluosilicate, paris green, or calcium arsenate with 10 pounds of dry wheat bran and moistening with 1½ to 2 gallons of water. Broadcast the bait late in the day at the rate of about 40 pounds per acre. Metaldehyde is highly toxic to man and other animals; therefore, handle it with care.

SPRINGTAILS

Springtails are tiny insects that jump like fleas and disappear when approached. The damage they cause is therefore often attributed to other insects. The garden springtail is the most common species. It may occur in swarms, feeding on the roots of potatoes and other crops. It may also attack the foliage, making characteristic pits in the under side of leaves or feeding along the surface injured by other insects. DDT dusts or sprays should control this insect in potato fields.

THREE-LINED POTATO BEETLE

The three-lined potato beetle occasionally feeds on potato foliage. The grayish-yellow larva of this beetle is recognized by the excrement covering its back. The adult is a yellowish-orange beetle about one-quarter inch long with three black stripes on the wing covers. It is found in the central and eastern parts of the United States and in Texas and California. For control use arsenicals as recommended for the Colorado potato beetle (p. 14).

THRIPS

Several kinds of thrips feed on the foliage of potato. The tobacco thrips feeds on potatoes in the South. The bean thrips attacks potatoes in the irrigated sections of the Salt River Valley of Arizona. In the onion-producing districts of Texas and Idaho the onion thrips sometimes damages potatoes. Thrips, or oat bugs, are very small, slender insects, gray, yellow, brown, or reddish. Except for their rapid serpentine movements, they might escape observation. Potato plants heavily infested with thrips become stunted and the yield is correspondingly reduced. Spores of the early blight fungus may readily attack injured leaves.

The DDT formulas recommended for control of aphids (p. 12) are effective against thrips.

LIST OF POTATO INSECTS

COMMON NAME	SCIENTIFIC NAME
Apple mealybug	*Phenacoccus aceris*
Arid leafhopper	*Empoasca arida*
Armyworm	*Pseudaletia unipuncta*
Ash-gray blister beetle	*Epicauta fabricii*
Banded flea beetle	*Systena taeniata*
Banded vegetable weevil	*Listroderes apicalis*
Bean thrips	*Hercothrips fasciatus*
Beet leafhopper	*Circulifer tenellus*
Beet webworm	*Loxostege sticticalis*
Black blister beetle	*Epicauta pennsylvanica*
Black cutworm	*Agrotis ypsilon*
Buckthorn aphid	*Aphis abbreviata*
Cabbage looper	*Trichoplusia ni*
Carrot beetle	*Ligyrus gibbosus*
Changa	*Scapteriscus vicinus*
Citrus mealybug	*Pseudococcus citri*
Clear-winged grasshopper	*Camnula pellucida*
Clover leafhopper	*Aceratagallia sanguinolenta*
Colorado potato beetle	*Leptinotarsa decemlineata*
Corn earworm	*Heliothis armigera*
Corn wireworms	*Melanotus* spp.
Cotton fleahopper	*Psallus seriatus*
Differential grasshopper	*Melanoplus differentialis*
Dingy cutworm	*Feltia subgothica*
Eastern field wireworm	*Limonius agonus*
Eggplant flea beetle	*Epitrix fuscula*
Eggplant tortoise beetle	*Gratiana pallidula*
European corn borer	*Pyrausta nubilalis*
European earwig	*Forficula auricularia*
Fall armyworm	*Laphygma frugiperda*
False chinch bug	*Nysius ericae*
Four-lined plant bug	*Poecilocapsus lineatus*
Foxglove aphid	*Myzus solani*
Garden centipede	*Scutigerella immaculata*
Garden fleahopper	*Halticus bracteatus*
Garden springtail	*Bourletiella hortensis*
Garden webworm	*Loxostege similalis*
Glassy cutworm	*Crymodes devastator*
Grape mealybug	*Pseudococcus maritimus*
Gray garden slug	*Deroceras reticulatum*
Greenhouse whitefly	*Trialeurodes vaporariorum*
Green peach aphid	*Myzus persicae*
Gulf wireworm	*Conoderus amplicollis*

COMMON NAME	SCIENTIFIC NAME
Harlequin bug	*Murgantia histrionica*
Intermountain leafhopper	*Empoasca filamenta*
Iris whitefly	*Aleyrodes spiraeoides*
Leaf-footed bug	*Leptoglossus phyllopus*
Leaf miners	*Liriomyza* sp.
Lesser migratory grasshopper	*Melanoplus mexicanus mexicanus*
Margined blister beetle	*Epicauta solani*
Millipedes	*Julus* spp.
Northern mole cricket	*Gryllotalpa hexadactylo*
Onion thrips	*Thrips tabaci*
Pacific Coast wireworm	*Limonius canus*
Pale plant bug	*Lygus elisus*
Pale-striped flea beetle	*Systena blanda*
Pale western cutworm	*Agrotis orthogonia*
Potato aphid	*Macrosiphum solanifolii*
Potato flea beetle	*Epitrix cucumeris*
Potato leafhopper	*Empoasca fabae*
Potato psyllid	*Paratrioza cockerelli*
Potato scab gnat	*Pnyxia scabici*
Potato stalk borer	*Trichobaris trinotata*
Potato tuberworm	*Gnorimoschema operculella*
Prairie grain wireworm	*Ctenicera aeripennis destructor*
Rapid plant bug	*Adelphocoris rapidus*
Red-legged grasshopper	*Melanoplus femur rubrum*
Say stink bug	*Chlorochroa sayi*
Seed-corn maggot	*Hylemya cilicrura*
Seed potato maggot	*Hylemya trichodactyla*
Short-winged mole cricket	*Scapteriscus abbreviatus*
Six-spotted leafhopper	*Macrosteles divisus*
Solanum mealybug	*Phenacoccus solani*
Southern armyworm	*Prodenia eridania*
Southern green stink bug	*Nezara viridula*
Southern mole cricket	*Scapteriscus acletus*
Spotted blister beetle	*Epicauta maculata*
Spotted cucumber beetle	*Diabrotica undecimpunctata howardi*
Spotted cutworm	*Amathes c-nigrum*
Spotted garden slug	*Limax maximus*
Stalk borer	*Papaipema nebris*
Striped blister beetle	*Epicauta vittata*
Striped cucumber beetle	*Acalymma vittata*
Sugar-beet wireworm	*Limonius californicus*
Tarnished plant bug	*Lygus oblineatus*
Tawny garden slug	*Limax flavus*
Three-lined potato beetle	*Lema trilineata*
Tobacco flea beetle	*Epitrix hirtipennis*
Tobacco hornworm	*Protoparce sexta*
Tobacco stalk borer	*Trichobaris mucorea*
Tobacco thrips	*Frankliniella fusca*
Tomato hornworm	*Protoparce quinquemaculata*
Tuber flea beetle	*Epitrix tuberis*
Two-spotted spider mite	*Tetranychus bimaculatus*
Two-striped grasshopper	*Melanoplus bivittatus*
Variegated cutworm	*Peridroma margaritosa*
Vegetable weevil	*Listroderes costirostris obliquus*
Western plant bug	*Lygus hesperus*
Western potato flea beetle	*Epitrix subcrinita*
Western potato leafhopper	*Empoasca abrupta*
Western spotted cucumber beetle	*Diabratica undecimpunctata*
Western striped cucumber beetle	*Acalymma trivittata*
Wheat wireworm	*Agriotes mancus*
White-fringed beetles	*Graphognathus* spp.
White-lined sphinx	*Celerio lineata*
Yellow-striped armyworm	*Prodenia ornithogalli*
Yellow woollybear	*Diacrisia virginica*
Zebra caterpillar	*Ceramica picta*

PICTURE SHEETS

The Bureau of Entomology and Plant Quarantine has issued the following Picture Sheets illustrating in color and describing several of the insects discussed in this bulletin.

No. 1, Tomato Hornworms.
No. 3, Colorado Potato Beetle.
No. 5, Harlequin Bug.
No. 7, Striped Cucumber Beetle.
No. 8, Potato Leafhopper.
No. 11, Corn Earworm.
No. 12, Fall Armyworm.
No. 14, European Corn Borer.
No. 18, Cotton Flea Hopper.

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